The impact of the cost of car ownership on the house price gradient in Singapore

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\textbf{A B S T R A C T}

This paper examines the extent to which a change in the cost of car ownership affects the house price gradient with respect to distance from the central business district (CBD). Theory suggests that if the cost of owning a car increases, people will use other modes of transportation, thus reducing house prices farther away from the CBD and increasing house prices closer to the city center. However, in an empirical setting, the cost of car ownership is likely to be endogenous and correlated with various unobserved factors that also contribute to changes in the house price gradient. To obtain causal effects, we exploit a unique feature of Singapore’s car registration process. All cars in Singapore must have a Certificate of Entitlement (COE), but the number available is restricted based on the traffic concerns of the government and are allocated through a competitive bidding process. The number of COEs available each quarter as an instrument for the price of a COE, as the quasi is likely to be correlated with the price of the COE but not the price of housing at various distances from the CBD. We find that when the price of a COE increases, the price of housing closer to the city center increases, suggesting that increases in the price of a car cause individuals to increase their willingness to pay to locate closer to the CBD.

1. Introduction

The price distribution of housing throughout a city has been of interest to urban economists since the advent of the monocentric city model (Alonso, 1964; Muth, 1969; Mills, 1967; Wheaton, 1974; Brueckner, 1987). The monocentric city model argues that there are different factors that affect the price of housing relative to distance from the city center. For example, as transportation costs increase, individuals will be willing to pay more to locate closer to the central business district (CBD) so that they do not have to travel as far to work.\textsuperscript{1} However, estimating the effect of transportation costs on the urban price gradient is problematic, as the costs are likely correlated with various unobserved factors that contribute to the house price gradient. To address endogeneity concerns, we examine the house price gradient in Singapore, as the unique nature of the car registration process allows us to obtain supply-driven, exogenous variation in the price of car ownership to identify a causal relationship.

The city-country of Singapore offers a unique opportunity to study the urban price gradient due to a key feature of its transportation policy aimed at reducing road congestion. To own a car in Singapore, like most countries, you must obtain a registration, known as a Certificate of Entitlement (COE).\textsuperscript{2} However, unlike most countries, the government restricts the number of COEs available to curb growth of the number of cars and hence to reduce traffic. To distribute the limited number of COEs, the government allocates the registrations through a competitive on-line bidding process.\textsuperscript{3} Therefore, the price of a COE, which is a significant portion of the price of acquiring a car in Singapore, varies over time based on the number of registrations available each auction. The high cost of obtaining a COE is one of the primary reasons that car ownership rates are so low in Singapore (Chu, 2014, 2015).

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\textsuperscript{1} Glaeser et al. (2008) found that the poor tend to live in cities due to reliance on public transportation, consistent with predictions from this model.

\textsuperscript{2} Singapore also engages in congestion pricing practices. However, since we are not studying congestion specifically in this paper, we do not discuss the details of this policy. For more information on congestion pricing, see Verhoef (2002), Saleh (2007), Larsen et al. (2008), Eliasson et al. (2009), and De Lara et al. (2013).

\textsuperscript{3} We discuss the auction process in detail later in the paper.
We estimate the extent to which house prices throughout Singapore vary with respect to distance from the CBD as transportation costs, specifically the price of a car, change.\(^5\) To obtain causal estimates, we use the number of COEs released by the Land Transport Authority as an exogenous, supply-driven instrument for the price of a car. The number of COEs released each auction is based on the government’s desire to reduce congestion and is unlikely to be affected by the future change in house prices throughout the city. Therefore, we use the number of COEs released each quarter as an instrument for the price of a COE and hence the price of a car. Our first stage regressions support the use of the number of COEs as an instrument for the price of a COE.

Using the number of COEs allocated in a given quarter as our instrument, we examine how the price of housing varies with respect to distance from the city center as the price of a COE, and hence the price of a car, changes. To do so, we obtained proprietary information on residential property sales in Singapore from 2002Q2 to 2015Q4. To control for house-specific characteristics other than distance to the city center, we exploit a homogeneity feature of Singapore’s private residential market to include “unit” specific fixed effects. This is a viable option because all units within each residential project are homogeneous, with the same interior design, the same furnishings, the same major electrics, and the same outdoor facilities. In this context we have high-frequency transaction records for almost identical units in the property sales market (Baltagi and Li, 2015). This feature of the Singaporean private housing market enables us to frequently trace the change in house prices at various distances from the CBD while including “unit” (project) fixed effects.

We find that higher COE premiums are associated with higher house prices for units that are closer to the CBD. Specifically, we find that if the COE premium increases from $10,000 to $40,000, which is how much the premium increased between 2009 and 2010, the price of centrally located housing increases by approximately 8.37%. At the same time, we find that this increase in house prices declines with distance from the CBD. For those units that are 10km away from the city center, the same increase in the COE premium is associated with only a 2.19% increase in house prices. In other words, the percent increase in the price of housing for units 10km from the CBD is approximately four times less than the price increase of centrally located housing units. This result supports the predictions of the monocentric city model, allowing for alternative modes of transportation (i.e. private or public transportation). Our findings are consistent across various specifications, such as using different time trends as controls, using different definitions of the CBD, restricting the sample to only those units that are sufficiently far from a subway stop that residents are more likely to rely on cars for transportation, and to including different types of COE registrations.

Our results are consistent with the literature on the “negative rent gradient,” which has been discussed extensively in the urban economics literature.\(^5\) To estimate the effect of transportation costs on house prices at various distances from the CBD, prior studies have mainly considered time costs and gasoline prices. For instance, Coulson and Engle (1987) and Blake (2016) found that increases in gas prices increased the price of centrally located houses. Anas and Chu (1984) reported that the probability of living in a given neighborhood is decreasing in average travel time and travel cost to the city center. Cortright (2008) showed that house prices fell more in ZIP codes with longer commutes after an increase in gas prices. Molloy and Shan (2013) found that an increase in gasoline prices led to a decrease in new home construction in locations with longer commutes, but found no significant effect on existing house prices. Accounting for both monetary and time costs, Tse and Chan (2003) found evidence of a negative rent gradient using data from Hong Kong, versus the other studies mentioned which focused on the U.S.

We contribute to this literature by examining the effect of a change in the acquisition costs of car ownership on the house price gradient. In the U.S., the car ownership rate is high and usage costs, both monetary and non-monetary, are generally larger than the acquisition costs (Ferdous et al., 2010). However, in jurisdictions where the government institutes traffic control policies, such as Shanghai and Singapore, the per-capita car ownership rate is low (12 cars per 100 people in Singapore) and the cost of acquiring a car is substantially larger than the usage costs (Chu, 2014, 2015). This implies that the acquisition cost of car ownership may affect the house price gradient through its impact on the demand for a car versus other types of transportation. We expand upon the literature by examining how changes in the acquisition costs of a car affect the price of housing at various locations throughout the city using a closed urban model with two modes of transportation. Furthermore, our identification strategy is novel within the urban price gradient literature as we use an exogenous change in the supply of car registrations, which is unlikely to be correlated with other demand factors influencing the house price gradient, as an instrument for the price of a car. While the use of such supply side instruments is becoming increasingly popular in the economics literature, we are the first to utilize this type of instrumental variables approach to estimate the urban price gradient.\(^6\)

The rest of the paper will proceed as follows. Section 2 discusses the institutional details of vehicle ownership and the housing market in Singapore. Our theoretical model is presented in Section 3, Section 4 outlines our identification strategy and we discuss our data in Section 5. Section 6 describes our main results and we show a series of robustness checks in Section 7. We conclude in Section 8.

2. Vehicle ownership and residential property market in Singapore

2.1. Vehicle ownership and costs in Singapore

According to the Economist Intelligence Unit (EIU)’s report in 2016, Singapore retained the title of the most expensive city in the world for the third consecutive year, and the price of owning a car is one of the factors that make the city-country so expensive. The Singaporean government has implemented several policies to reduce traffic and congestion, specifically congestion pricing\(^7\) and vehicle ownership restraint. As a result of these policies, the costs of owning a vehicle in Singapore are extremely high and subsequently the car ownership rate is low (Chu, 2014, 2015).

To curb the growth of the vehicular population, a vehicle quota system was introduced by the Singaporean government in May 1990 via the Certificate of Entitlement (COE) scheme. Vehicle owners must obtain a COE to purchase a car, but there are a limited number of these registrations available. Therefore, obtaining a COE is conditional on making a successful bid when buying a car. A COE is valid for ten years.

\(^5\) Glasser and Kahn (2004) argue that the declining cost of a car in the U.S. is one of the main reasons why American cities have become so sprawled. This suggests that the price of a car is important when considering transportation costs.

\(^6\) These supply-side instruments have become increasing popular since Saiz (2010) created estimates of the elasticity of supply for MSAs in the U.S. These elasticity estimates have been used in the literature to address demand-related endogeneity issues, including Mian and Sufi (2011, 2013) and Cvijanovic (2014) who use this measure to explain variation in house price appreciation across MSAs.

\(^7\) While congestion pricing is in effect in Singapore, we do not discuss it in detail as it is not the focus of our analysis. For more information, see Agarwal et al. (2015) and http://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/managing-traffic-and-congestion/electronic-road-pricing-erp.html.
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